

Summary Report

Investigation of Volatile Nitrosamines in Disposable Protective Gloves*

Laboratory personnel of Eastern Regional Research Center, USDA, are required to wear disposable latex or vinyl gloves for certain analyses involving nitrosamines. In order to assess possible exposure of the wearers of these gloves, a limited survey was carried out on the volatile nitrosamine content in disposable protective gloves. Six latex gloves, nonsterile and sterile, surgical and nonsurgical, from four companies, and four vinyl gloves from three companies were analyzed. N-nitrosodimethylamine (NDMA) and N-nitrosopiperidine (NPIP) were the primary nitrosamines detected. Five of the six latex gloves contained 37-329 ppb NDMA and 115-1879 ppb NPIP, all confirmed by gas chromatography-mass spectrometry (GC-MS); one glove contained no detectable trace of NDMA or NPIP. Of the four vinyl gloves, one contained 19 ppb NDMA and 759 ppb NPIP, both confirmed by GC-MS, one contained 6 ppb apparent NDMA and no detectable level of NPIP, and the remaining two contained no detectable levels of NDMA and NPIP.

Introduction

In 1980 our laboratory, Eastern Regional Research Center, USDA, reported that N-nitrosodimethylamine (NDMA), N-nitrosodiethylamine, and N-nitrosomorpholine (NMOR) leached from rubber stoppers of blood collection tubes into the blood anticoagulant solution.⁽¹⁾ This publication was the first to confirm, by GC-MS, nitrosamines in rubber products. Although the reports of nitrosamines in rubber nipples^(2,3) were preceded by another report,⁽⁴⁾ the former publications led to a number of research groups conducting surveys for volatile nitrosamines in rubber nipples used for baby bottles.⁽⁵⁻⁹⁾ Eventually one of these reports⁽⁶⁾ became the basis for regulating the limits on nitrosamines in these products in the United States.⁽¹⁰⁾ This action has recently led to the reformulation of the rubber to eliminate the secondary amino-containing accelerators and stabilizers, thus permitting regulatory compliance.

For the past 14 years, we have required that laboratory personnel wear thin latex or vinyl gloves for certain operations associated with nitrosamine analysis to avoid undue exposure. The use of protective gloves is a common practice in many laboratories where personnel are working with chemical carcinogens, radioactive compounds, pathogenic microorganisms or other hazardous materials. There is some information on the permeability of laboratory gloves to certain nitrosamines, and some assessment on the protection they offer people handling nitrosamines.⁽¹¹⁻¹³⁾ Also, since

nitrosamines would be expected based on the findings in other rubber products, some information is available on the nitrosamine content of these products. The information available, however, has been published as a part of larger surveys of rubber products,^(3,4) and may therefore be missed by people interested in this subject as evidenced by the lack of concern or activity in reducing levels of nitrosamines found in rubber products other than baby bottle nipples. From a very limited survey of disposable gloves, this report therefore provides additional data on the volatile nitrosamine content of protective gloves.

Experimental

Materials

Glass distilled dichloromethane (DCM) and pentane were obtained from Burdick and Jackson. Neutral aluminum oxide (Brinkman Instruments, Inc.) and silicic acid (Mallinckrodt) were activated in an oven at 190°C for 4 hours then deactivated by addition of 6 g distilled water/94 g aluminum oxide and 5 g distilled water/95 g silicic acid. Celite 545 was obtained from Fisher Scientific Company. All reagents were analyzed and found to be free of volatile nitrosamines. The gloves were from various commercial sources and all, except one, contained powder as was evident either by visual inspection, or by the presence or absence of powder as stated on the packages.

Methods and Analyses

The gloves were analyzed for volatile nitrosamines by the method described for rubber nipples.⁽⁶⁾ Briefly, the gloves were cut into 2 x 3 cm pieces and extracted with DCM. After an addition of 5 N NaOH, the DCM was distilled and discarded, then the aqueous distillate was collected and re-extracted with DCM. After concentration, the DCM extract was analyzed for nitrosamines using a gas chromatograph interfaced to a nitrosamine-specific Thermal Energy Analyzer (GC-TEA) detector, as previously described.⁽¹⁴⁾

Gas Chromatography-Mass Spectrometer (GC-MS) Analyses

The instrument used was a Hewlett-Packard Model 5992B GC-low resolution quadrupole mass spectrometer. Prior to GC-MS analysis the extracts containing apparent NDMA and N-nitrosopiperidine (NPIP) were cleaned up by passage through acid-Celite columns,⁽¹⁵⁾ followed by deactivated silicic acid (NDMA) and aluminum oxide (NPIP) columns. The following conditions were required for MS confirma-

*Reference to brand or firm name does not constitute endorsement by the U.S. Department of Agriculture over others of a similar nature not mentioned.

TABLE I

Volatile Nitrosamines in Rubber Latex and Vinyl Gloves

| Company | Sample No. ^A | Product | Nitrosamines, ppb | | |
|----------------|-------------------------|-----------------------------------|-------------------|-------------------|---------------------|
| | | | NDMA | NPIP | Others |
| Latex Glove | | | | | |
| 1 | 1,2 | | 76 ^B | 1879 ^B | 4, NMOR; 2, NPYR |
| | | | 329 ^B | 1808 ^B | |
| 2 | 3 | "sterile nonsurgical" | 46 ^B | 547 ^B | |
| | 4 | "sterile surgical" | N.D. ^C | N.D. | |
| 3 | 5 | "sterile surgical" (talc-free) | 37 ^B | 115 ^B | |
| 4 | 6 | | 34 ^B | 238 ^B | |
| Vinyl Glove | | | | | |
| 5 | 7 | "Medical" | 19 ^B | 759 ^B | |
| 6 | 8 | | N.D. | N.D. | |
| 7 ^D | 9 | | 6 | N.D. | |
| 8 | 10 | | N.D. | N.D. | |

^A10 g sample.^BConfirmed by GC-MS.^CN.D. = not detected, ≤ 1 ppb.^DA division of Company 6.

tion: NPIP, a mass spectrum that was identical to that of the NPIP standard; and NDMA, the presence of three principal ions before and their absence after ultraviolet light photolysis by a technique previously described.⁽¹⁶⁾

Safety Note

Precaution should be exercised in the handling of nitrosamines since they are potential carcinogens.

Results and Discussion

A total of 10 glove samples, 6 latex and 4 vinyl, from 7 companies were analyzed for volatile nitrosamines. Whether the manufacturers of these vinyl and rubber latex products were also the compounders and/or distributors of the elastomers used was unknown. The latex gloves contained 37-329 ppb NDMA and 115-1879 ppb NPIP, all of which were confirmed by GC-MS, except for one sample of sterile latex surgical glove in which only low levels of apparent NMOR and N-nitrosopyrrolidine (NPYR) were detected. These results are summarized in Table I. The source of the low levels of apparent NPYR detected in this study was also unknown. Low levels of NPYR have also been reported in a tire manufacturing plant,⁽¹⁷⁾ but this nitrosamine was unexpected since pyrrolidine-containing compounds normally are not used as a rubber additive.⁽³⁾

The precursors for nitrosamine formation, a secondary amine and a nitrosating agent, are present during the manufacture of rubber and rubber products. It has been demonstrated that the dialkylamino-containing accelerators and stabilizers added during the vulcanization process are the source of the secondary amines.^(6,18) Dimethylamine, piperidine, and morpholine, but not pyrrolidine, are some of the secondary amines commonly used. The nitrosating agent for

nitrosamine formation is not known at present, but among the suspected agents, nitrogen oxides are known to nitrosate secondary amines and are present in the contaminated air of a rubber manufacturing plant.⁽⁶⁾

One of the gloves labelled "vinyl" contained 19 ppb NDMA and 759 ppb NPIP, both confirmed by GC-MS. Of the remaining three, only 6 ppb apparent NDMA was detected in one sample and none detected in the other two. While the source of the nitrosamine in the "vinyl" glove is unknown, it is suspected that some latex rubber may have been added during compounding to impart the greater elasticity observed in these gloves compared to the others in the same category. The nitrosamine-positive latex glove from Company 3 and the "vinyl" glove from Company 5 are commonly purchased and used in our laboratory. The other vinyl gloves were purchased by other workers at ERRC for their use, whereas the other rubber latex gloves were obtained from a local hospital in order to make an assessment of their nitrosamine content.

After the finding of relatively high levels of NDMA and NPIP in the latex glove from Company 1 and the low levels in the sterile surgeon's glove sample (Company 2), it was thought that the latter resulted from gamma irradiation, which is commonly used to sterilize these products. We had previously found that gamma irradiation with C_{60} at 3.0 Mrad (30 kGy) destroyed NPYR in fortified raw and fried bacon.⁽¹⁹⁾ Therefore, we took three sets of latex gloves from each of two different boxes (samples 1 and 2) from Company 1 and arranged to have them irradiated at 1.8 and 3.5 Mrad, levels slightly lower and greater than that commonly used to sterilize these products. The limited NDMA and NPIP results were extremely variable, possibly in part due to variation in composition and sampling. However, there was no

evidence of nitrosamine destruction with either dose level compared to the controls. Therefore, the lower nitrosamine content of some of the latex gloves may have resulted from formulation differences.

Conclusion

There is a potential concern to users of these nitrosamine-positive gloves since the wearer may use them for extended periods, allowing the nitrosamines present to be leached from the gloves by perspiration, followed by dermal absorption. Due to the inefficiency of this process, only a small concentration of the total nitrosamines in the gloves would be expected to be leached out. The permeability of the glove materials to certain organic solvents would also increase the amount of nitrosamine at the skin surface and perhaps facilitate absorption. While the actual human exposure is difficult to assess, it would be prudent, if possible, to reduce or eliminate exposure to these potentially carcinogenic nitrosamines. We have therefore limited laboratory personnel to using the nitrosamine-free vinyl gloves whenever possible. This is considered essential given the earlier reports of limited protection afforded by the latex gloves should a spillage of organic solvents, particularly a solution of nitrosamines in DCM, occur.⁽¹¹⁻¹³⁾ DCM is the most common solvent used in nitrosamine analysis. This is why we also recommend discarding the gloves immediately after contamination. Since this report presents results from only a limited number of samples, we urge that the responsible regulatory agencies conduct a comprehensive survey of these rubber-latex gloves.

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